AUDITORY AND VISUAL MECHANISMS IN FOOD-FINDING BEHAVIOR OF THE HERRING GULL

BY HUBERT FRINGS, MABLE FRINGS, BEVERLEY COX AND LORRAINE PEISSNER

THERE are many places along the sea-coast where gulls (*Larus* sp.) regularly gather to feed: refuse dumps, fish-processing factories, docks where fish are loaded and unloaded. Dumps are almost always littered with edible materials, and gulls stay on them all day. They obviously learn to recognize trucks bringing food and flock in whenever one of these appears. Fish-processing factories and fishing wharves are also closely observed by gulls. At sardine packing plants where the offal is carried to bins by a "chum belt," the mere sound of the motor driving this belt immediately attracts those gulls within hearing range. In these cases, the association between food and sensory cues may be either visual or auditory, and it is obviously learned.

In specialized situations, such as these, it is easy to explain the accumulation of flocks of gulls as food becomes available, if one is satisfied to know merely the sensory cues involved. But at most places on the sea-coast one sees only an occasional gull flying over the water's edge or poking the sea-weed looking for tid-bits. Yet one need only throw fish or other food into or near the water, and gulls accumulate rapidly. What brings them from such distances to this food?

Fishermen and other coast-dwellers believe that gulls have a keen sense of smell, or that they have a "sixth sense." None of the scientists who has studied the behavior of gulls, certainly among the most studied of birds, has dealt with this behavior pattern.

Obviously, this attraction to unfamiliar food sources is the first step in habituation to a feeding area; consistent feeding soon results in a large resident, trained population. The original attraction almost certainly involves some means of communication among the gulls. For these reasons, it seemed of interest to study how gulls become aware of food and transmit this information to other gulls where no local predilections or permanent aggregations existed.

General Procedures

The study was made on the coast of Maine, mostly near Salisbury Cove on Mount Desert Island. This island has a highly indented, rocky coastline, with many coves and projecting points of land. Any place on the coast, therefore, can be seen only for a short distance (less than one kilometer) from the same shore. At almost all places, there is a visible opposite shoreline, across a bay. Where this work was done, the opposite shore is about

four to five km. distant across open water. Many smaller rocky points and projections produce extremely limited cones of visibility at some places.

The studies were confined almost exclusively to the Herring Gull (*Larus argentatus*) which is the most common gull of this region. The Great Black-backed Gull (*Larus marinus*) is present in small numbers also, and some observations were made on it.

The major work was done from June 30 until August 28, 1954, experiments and observations being made only in non-stormy weather. The observation areas were at some distance from the breeding grounds of the gulls, and there was no evidence of breeding behavior. About July 1, juvenile gulls appeared with the others and increased in numbers until midsummer. There was no feeding of these immatures by the adults, although once or twice young were seen begging fruitlessly for food. In general, the behavior patterns associated with breeding and rearing young, as described so admirably by many earlier workers (Goethe, 1937; Tinbergen, 1953), were not observed. These gulls seemed intent only upon finding food for themselves, and otherwise merely rested on the water or on the rocks.

To separate auditory from visual cues in food-finding, the sounds made by the gulls were recorded with a tape recorder (Pentron, Model 9T-3C) and later broadcast to the birds through the recorder coupled with an amplifier (Stromberg-Carlson, Model AU42, 15 watts output) and one or two trumpet-type loud speakers (University Model PA 30). When specific calls were found to give specific behavioral responses, these were re-recorded from original tapes onto continuous repeating cartridges and broadcast with a small repeating tape recorder ("Message Repeater") through the amplifier and speakers. Power was supplied either by connection with available 110-volt, 60-cycle source or by converters activated by 6-volt storage batteries.

Possible Sensory Mechanism used in Food-finding

Where interpretation is relatively simple, such as at factories, learned visual or auditory cues are used by the gulls in food-finding behavior. These two senses, therefore, suggest themselves as probably involved in the wild conditions. Such an idea would be further supported by the well-known visual and auditory powers of these birds (Tinbergen, 1953). The visual cues which might attract gulls to a site previously not associated with food include: (1.) the presence of a human being; (2.) the act of throwing something by a person; (3.) the fish being thrown or placed; (4.) the splashes made by the fish, if thrown into water; (5.) the behavior of other gulls which have discovered the fish. The auditory cues include: (1.) the sound of the splashes made by fish thrown into the water; (2.) the calls of other gulls.

A common belief among fishermen, however, is that these birds have an acute sense of smell, in spite of the ornithologists' dictum that olfaction is generally poorly developed in birds. The idea that the gulls use an extra sense not possessed by man can only be admitted if the accepted distance senses fail to account for attraction to food-sources.

The Role of Olfaction in Food-finding

Presumably the odor of fish could attract the gulls. Tests of this hypothesis were easily made. Fish with a distinct odor, slightly rotten but still acceptable to gulls, were wrapped in a piece of thin paper and placed on a rock. A similar bundle containing stones was placed nearby on another rock. Some gulls had previously been attracted by slight feeding and these were afloat on the water within easy sight and presumably within easy range of the odor. The observers could smell the fish from their observation post, which was farther from the fish than was the gulls' observation post.

The gulls gave no indication of interest in the bundles. A few flew over, but without any sign of recognition of the food that was easily available. After about 15 minutes of this, a few fish were scattered about the rocks near both bundles. As soon as the observers left the spot, the gulls came to feed. They ate the fish which were visible, even picking up fish lying immediately alongside of the bundle containing the others. At no time did they show any interest in the odorous bundle containing the fish, although they could easily have torn it open and got them all. A repetition of feeding showed that the gulls were still hungry.

These bundles remained on the rocks from 2:30 p.m. until dark, about 8:00 p.m., and were untouched by the gulls. Early the next morning a cat found the wrapped fish and ate them. The cat, with its excellent sense of smell, was not fooled by the paper. The obvious conclusion is that olfaction plays little or no role in food-finding by the Herring Gull, a conclusion which supports earlier reports (Strong, 1914; Tinbergen, 1953).

The Role of Vision in Food-finding

If visual cues are used by the gulls in aggregating at food sources, the first question which arises is: how well do the gulls, as a population, have any given point on the coast under visual surveillance?

There is plenty of evidence that the sense of sight of most birds, including Herring Gulls, is at least as good as that of man (Donner, 1951; Tinbergen, 1953). Conceivably it might be better. Therefore, if a human observer at any given place on the coast can see a gull, it is reasonable to suppose that the gull can see the observer and would have that point under visual surveillance.

Counts were made of the gulls that could be seen afloat, resting on rocks, or flying at many places on the coast. Two methods of counting were used: the observer kept a continuous record of the gulls in sight, or the observer made a count every 30 seconds of the number of gulls in sight. The latter method proved to be simpler and quite useful for graphical presentation.

These counts showed that every point on the coast was under almost constant surveillance from floating, sitting or flying gulls. Only rarely would two or three minutes go by without a gull's passing in flight. Later experiments, in which gulls were attracted by feeding, showed that there were gulls floating on the water which had not been seen. It is difficult to see a floating gull from the land, with the sun glancing from the waves. It is quite easy to see an object on the shore from the water. The seemingly immediate attraction of a few gulls on throwing food could, therefore, result from visual cues.

Three of the suggested visual cues—human beings, the act of throwing, and the splashes—can be disposed of easily. The part of the shoreline where most of these experiments were made was traversed by many people each day, and tourists often stopped to admire the view. There was no apparent attraction of gulls to human beings if they merely stood on the shore. At special picnic areas for tourists, gulls often gathered, and there they were attracted by human beings, but not on the open coast. The act of throwing and the sight of splashes also were not, in themselves, attractive on the open coastline. One could throw stones without arousing much interest on the part of the gulls, unless he had previously been throwing fish. Occasionally, as one would start to throw or skip stones, a gull would fly from its resting place toward the spot, but this was not usual. This is not to suggest that splashing cannot become attractive, through learning, as happens near docks or boats where feeding is regularly done. Under conditions where learning is not involved, however, splashes or throwing as well as mere presence of a human being, are not attractive to gulls.

To test the possibility that the sight of fish being thrown is attractive to the gulls, artificial fish were made from pieces of aluminum foil molded into fish-like shapes. At a distance, these flashed in the sunlight as real fish did, but at close range they were obviously distinguishable from the real thing. They were tested by being treated, in the sight of gulls, as if they were real fish being thrown.

In one experiment, for instance, the gulls were resting on the water at a distance of about 0.5 km. from the place where the decoys were thrown. The gulls thus were able to see the flashing from the artificial fish, but at that distance presumably could not distinguish them from real fish.

The results are shown in Figure 1. Counts were made, at 30-second intervals, of gulls within a 15-meter radius of the place where the decoys were being thrown. At the start, there were three gulls resting on the water near the spot; the others were, as noted, at some distance. As soon as the decoys were thrown, even though the first were thrown on the shore to avoid splashing, the distant gulls rose into the air, flew over the artificial fish and formed a group on the water. Once they could clearly see the artificial fish, they were not interested in them as food, however. One imitation floated out into the interest-group, but only a first-year gull pecked at it a few times in a desultory manner. The others ignored the decoys, and shortly flew away, when nothing more substantial was offered.

Other tests substantiated these results. The flashing of objects through the air is attractive to gulls. A similar response was observed at a sardine cannery, where damaged tin cans thrown from a window attacted the gulls' attention. In the experiment described above, a situation was selected in which

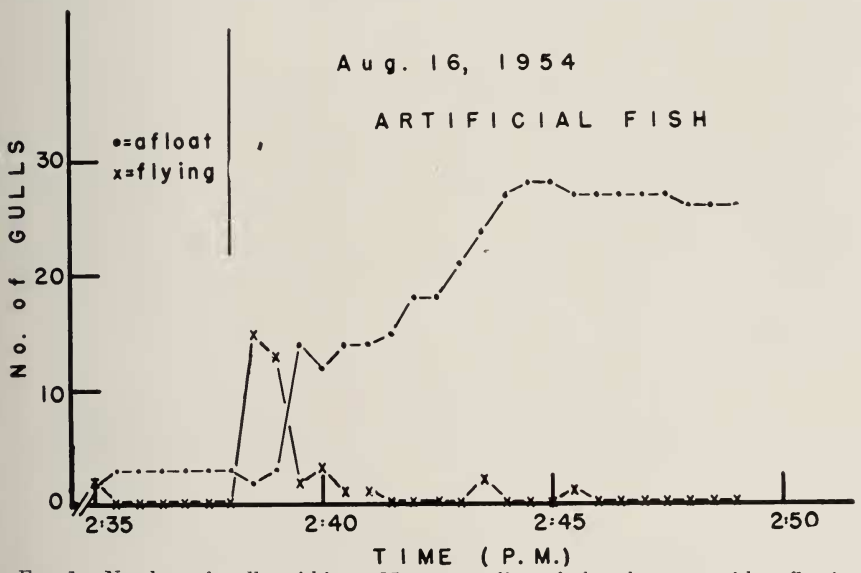

Fig. 1. Number of gulls within a 15-meter radius of the observers, either floating on the water (●) or flying (×), during sham feeding. From 2:35–2:38, there were no untoward activities by the observers. From 2:38–2:40, artificial fish made of aluminum foil were thrown on the shore and in the water and left there for the remainder of the test.

many gulls were near enough to see the flashes. Under ordinary circumstances, with few gulls able to see a given part of the coast, the response is quite small. Thus, this alone does not account for aggregation of large numbers under normal circumstances.

The flash alone is not sufficient to cause gulls to try to feed. If the gulls are close, so that they can clearly see the artificial fish, they do not approach at all. Or, if the artificial fish are scattered about on the rocks, flying gulls give them only passing attention.

The last visual possibility is the behavior of other gulls as witnessed by the birds. There are two patterns of behavior which gulls exhibit when they sight food that could attract others. First is a special flight pattern over the food. If a flying gull sights food, it executes a "figure-8" pattern of flight over the area, losing altitude on the straight arms and gaining altitude as it circles at the ends. This flight pattern, if continued for more than two or three turns, induces other gulls within sight to approach, even though the flying gull remains silent. If food is present and recognizable, they too will execute "figure-8's." If this alone were active, however, only a few gulls would arrive in a short time.

The second behavior pattern is the tendency to accumulate in interest-groups on the water near food. Once an interest-group has formed, other gulls flying near will approach, even though the gulls in the group are silent. If food is present, they will join the group. Actually, the interest-group is not an original attractant and acts late in the attractive sequence, because it requires the prior presence of a number of gulls.

Thus, in the situation here studied, two visual cues can be used by the gulls in food-finding: the flashing of fish-like objects and the flight-pattern of gulls which have discovered food. While every spot is under constant visual surveillance the number of gulls which can see any given spot at any time is usually small. Thus they cannot account for the rapid accumulation of large numbers of gulls.

The Role of Audition in Food-Finding

At breeding areas, Herring Gulls are quite vocal, (Goethe, 1937; Tinbergen, 1953). Under the conditions of these studies, they were mostly silent, except during the feeding or shortly after dawn when they engaged in some vocalization, mostly restricted to trumpeting and mewing, described below.

There was plenty of evidence that auditory cues were of great importance in food-finding. This is well illustrated by the data shown in Figure 2. In this case, counts of gulls within sight at any distance were made at 30-second intervals, at first with no untoward activity on the observers' part, then when stones were splashed into the water, and finally when fish were thrown. The slight interest aroused by the splashing of stones is plain. As soon as fish were thrown, one of the gulls nearby emitted a special call, which was later taken up by others off and on, as indicated on the graph. Immediately, gulls began to come to the spot. These were not merely gulls that had been near-

by; the graph shows all gulls which were visible, regardless of distance. The gulls flew toward the spot from around neighboring high points of land, even over the tops of trees on the points. It is this attraction of gulls from places where they cannot see the food that has led fishermen to postulate a gull "radar."

There were two sounds which might be active, the splashing of the fish and the calls of the gulls. Splashing could almost be ruled out without further tests, on the basis of many experiments such as that described above. Perhaps, however, one might think that fish make splashes which the gull can distinguish from those of stones. Two tests were made of this. First, at a place on the coast where a number of gulls were resting on rocks we mounted a large rocky point of land about 0.5 km. away from the gulls. This point shielded our activities from their view but not from their hearing. There stones were thrown into the water, with no interest on the part of the gulls. Then fish were thrown into the water. Again the mere splashing sounds were unattractive. Climbing on the rock, so that the gulls could see, we threw

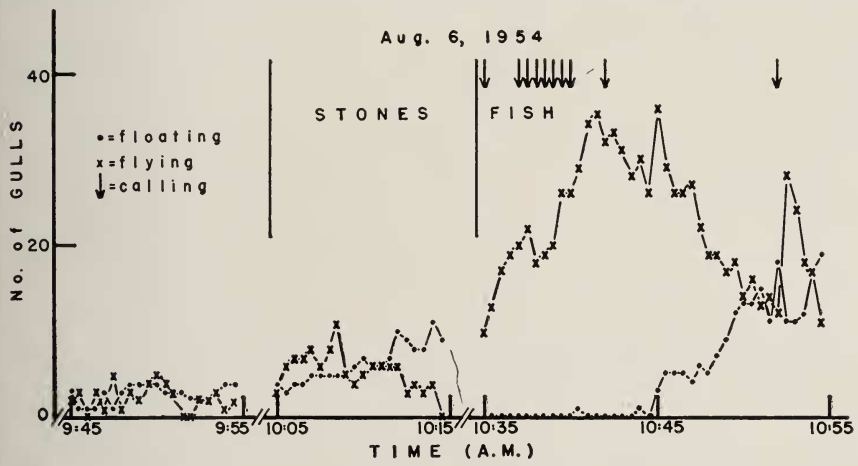

Fig. 2. Number of gulls in sight, either floating on the water (●) or flying (×), before and during feeding with fish. From 9:45–9:55, there were no untoward activities by the observers. From 10:05–10:15, stones were thrown into the water noisily. From 10:35–10:55, fish were thrown into the water. The times at which the special call of gulls at feeding areas was given are indicated by the arrows.

stones first, then fish. The gulls remained on the rocks when stones were used, but came immediately when fish were used. In this case, there was no interest in mere splashes. The interest in splashes of stones in the tests shown in Figure 2 was probably due to the fact that the experiment was done where the gulls had been fed previously.

The second test of the attractiveness of splashes was made with recorded

splashes. Both stone-splashes and fish-splashes were recorded, again with the possibility in mind that gulls might be able to distinguish between them. These splashes were played to gulls under many different conditions. At no time was there more than transient interest, nor any sign of differentiation by the gulls between the splashes. If a gull were flying quite near to the loud-speaker, it would turn as the splash sounded as if looking for the source. When this was not apparent, it paid little further attention.

Very early in the work, we noted a special call given on the wing by gulls when they found food in quantity. This call we later named the food-finding call, after its importance in this activity was found. It has three main notes, the middle one higher-pitched than the other two and accented. So

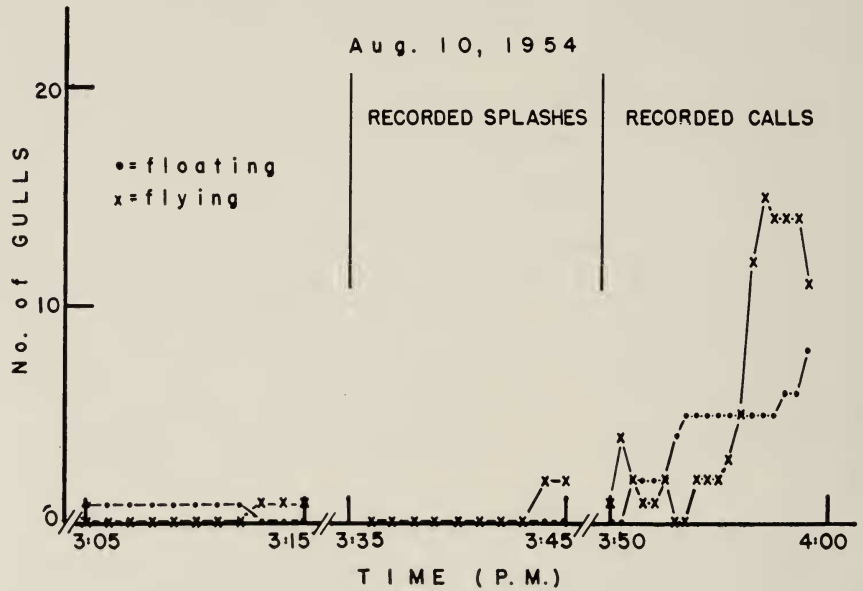

Fig. 3. Number of gulls in sight, either floating on the water (●) or flying (×), during tests of attraction by sounds. From 3:05–3:15, there were no untoward activities by the observers. From 3:35–3:45, recorded splashes made originally by throwing fish in water were broadcast. From 3:50–4:00, the recorded food-finding call was broadcast.

far as we can determine from syllabic renditions in the literature or descriptions of behavior to calls by earlier workers, the significance of this call has not been recognized previously. After our failure to decipher earlier workers' syllabic designations of calls (unaccompanied by descriptions of the actions of the birds), we conclude that it is useless to invent syllables to represent this or any call. It can be heard by anyone who so desires merely by feeding gulls, or we would be glad to exchange recordings, where feasible.

As Figure 2 shows, this call seemed to bring in many gulls. It was

recorded, therefore, and played back without presentation of food. The results of one test are shown in Figure 3. The counts represent all gulls visible to the observers, and the observers in this case were on a point of land rising sharply about 10 meters above the bay, so that visibility in all directions over the water was excellent. One gull was in sight, afloat near the point, as the counts began. This individual remained thus for eight minutes, then flew up and circled around. The counts was repeated as before, without activity on the part of the observers, with the same results (not shown on the graph). After that, the recorded sound of splashes made by throwing fish into the water was broadcast. As can be seen, no gulls were attracted. Following that, the recorded food-finding call was broadcast. This was mixed, in the recording, with squeaks of immature gulls which had been with the adults when the original recording was made. The results shown on the graph speak for themselves. The gulls which came toward the speakers flew over treetops and around points of land which certainly cut off their vision, had there been anything to see. They flew around the area, then settled on the water in an interest-group. When the sound was turned off, they stayed for 10 or 15 minutes and then dispersed one by one.

These observations were repeated many times at many places along the coast and even up to three or four km. inland. The gulls on this coast seem to have a much greater degree of auditory surveillance than of visual surveillance. So far as could be determined, auditory surveillance of any spot by many individuals was essentially continuous.

There was no doubt that the food-finding call attracted gulls within hearing range. It remained to be seen whether this call was specific or whether any call by gulls would be attractive. For tests of this, the calls of Herring Gulls were recorded under many different circumstances and later broadcast to the birds. The behavior of the gulls was observed as other gulls emitted the calls and when the recorded calls were played. On the basis of these tests, we were able to identify five or possibly six calls to which distinct reactions are given.

The Herring Gull's Vocabulary

The food-finding call.—This has already been described. The only syllabic and notational representation in earlier reports which seems similar is given by Goethe (1937) as one of the many under "Lock und Wanderruf," but he does not identify it as having any special significance. Collias and Joos (1953) have identified a food-call in the domestic fowl to which the chicks react by approaching the source.

The food-finding call of the Herring Gull is emitted when gulls see food, particularly if other individuals are already present and there is food in

some quantity. It is interesting to note that small quantities of food discovered by one gull will usually be consumed without vocal announcement, while large quantities will elicit the call.

The trumpeting call.—We designated the second clearly-defined call with this term, adopting the one used by Bent (1921), Tinbergen (1953) and others. This has been described in detail by earlier workers, and it has considerable significance during breeding (Portielje, 1928; Goethe, 1937; Tinbergen, 1953). The only reaction to it in feeding (non-breeding) gulls seems to be occasional chorusing. Gulls feed on dumps in large numbers, and, during the feeding, there is an almost incessant chorus of trumpeting, mixed with other calls. The only evidence, however, of a special reaction to the trumpeting is imitation on the part of other gulls. The same results could be obtained with recorded trumpeting.

The mew call.—The third clearly defined call is the "mew call," a term used by Strong (1914) and Tinbergen (1953). This likewise has been described by many other earlier workers: Boss (1943) as "cat-like," Portielje (1928) as "Zärtlichkeitsausdruck," Goethe (1937) as "Nestruf." The last two terms suggest that this is used only during breeding. It is common all summer among non-breeding Herring Gulls. The acoustically descriptive term, "mew" call, seems thus to be preferable. It sounds much like the mewing of a cat, mournful and somewhat ridiculous.

The functions of this call in mating and brooding behavior have been fully described by Goethe (1937) and Tinbergen (1953). In the case of non-breeding gulls, we were unable to discover any definite reaction to it. Often the mewing individual would be alone on a rock and would continue with this sound for long periods of time. Occasionally, the sad solo would be punctuated by the trumpeting call, which would trail off finally into the mew call. At no time was any attraction observed as a result of this call, nor even joining in of other individuals, as with the trumpeting.

Once we observed what looked like the use of the mew call by one gull to direct a group of its fellows. Fish for the gulls had been thrown very close to the microphone of the tape recorder and the observers remained rather close. The gulls were quite wary, and, after initially coming in as if to feed, gathered in an interest-group about 10 meters away on the water, while one gull sat on a rock nearby. Whenever this gull was silent, the group on the water swam slowly toward the fish near the shore. When they came to within about four meters of the fish, however, the gull on the rock would begin the mew call. The others would then slowly swim back to their original stations. This continued for about half an hour, during which time the observers did not move appreciably, and the group of swimming gulls made a number of trips in and out. Finally a juvenile gull flew

over and landed at the fish. Immediately all the others swarmed in and the clamor drowned out the voice of the mewing gull. This may have been accidental, or it may have shown a use for this call, aside from those in the breeding season.

The alarm call.—The fourth clearly defined call has also been described previously. It was noted by Dutcher, *et al.* (1903), called the alarm cry or call by Strong (1914), Bent (1921), Boss (1943) and Tinbergen (1953), "Schrecklaut" by Portielje (1928) and "Angstlaut" by Goethe (1937). We have offered a description of it elsewhere (Frings, *et al.*, 1955) and adopted the term, alarm call. Usually it consists of two parts: (1) an attention call of two notes in a descending sequence given very sharply, and (2) the alarm call proper, consisting of two or more, usually three, repeated staccato single notes, with major accent on the first in each series. The attention call is possibly the "Charge Call" of Tinbergen (1953), the "Wutlaut" of Portielje (1928) and the "Schrecklaut" or "Warnruf" of Goethe (1937), although this cannot be decided clearly on the basis of their syllabic descriptions. We prefer to designate it tentatively as an attention call, because it brings gulls up from their resting places and toward the source. It may be used also in conjunction with the food-finding call to bring gulls to feed. It thus seems to be ambivalent in effect, attractive or repellent, depending upon the intensity of expression and the sequel.

Earlier workers have described the circumstances under which the alarm call is emitted by gulls in a breeding colony. The call is most usually heard among foraging gulls when unusual circumstances exist near the feeding area. The presence of a person or a piece of equipment, such as a tape recorder, near the feeding areas induces some to give this call. The call is also given by gulls on sighting one of their fellows in the hands of a captor. This reaction may account for the repellency of captive or dead gulls to free birds. Our recordings were made as captive gulls were held in sight of others, or later during feeding at the place where the captive gulls had been exposed.

The reaction of gulls to the recorded alarm call is striking. With the first notes of the attention call, the gulls rise from their places of rest and fly toward the place from which the call arises. As the alarm call proper is given, they slowly fly away. Only one sequence of the call, consisting of the attention call and two or three repetitions of the alarm call will bring this about. In silence the gulls circle slowly higher and higher and finally out of sight.

The effect when this is done on a dump is rather uncanny. The dump may be crowded with hundreds of gulls, shrieking, trumpeting, flying around. When the alarm call is broadcast once or twice, the gulls rise into the air

as one, and in sombre silence glide away, with only a rare attention note from some individual in the flock. Within a few minutes, the dump is deserted and silent. The recorded alarm call was tested as a repellent for gulls on dumps and near fish-processing plants (Frings, *et al.*, 1955). It was possible to repel gulls from these areas and to keep them away for up to two full days merely by playing the recorded alarm call whenever they tried to return.

These four calls of the Herring Gull are found also in the repertory of the Great Black-backed Gull, but pitched about one octave lower. This was checked by recording calls of this species at a tape speed of 3¾ inches per second and playing them at 7½ inches per second, or the reverse with the Herring Gulls' calls.

There seemed to be almost complete cross-reactivity with these species of gulls in the food-finding and alarm calls. The calls of the Herring Gull were effective with Black-backed Gulls and vice versa. This is undoubtedly due to the flocking together of these species and the fact that the alarm calls of all gulls are quite similar (Bent, 1921). The alarm call of the Herring Gull was tested on Laughing Gulls (*Larus atricilla*) in New Jersey, and found to be effective in driving about 5,000 of them from a city dump. Thus there is considerable cross-reactivity in this case too.

Single-noted calls.—The fifth family of calls consists of grunts, clucks and other single-noted calls to which we observed no obvious reactions. These have also been mentioned previously, and Goethe (1937) has attempted an elaborate classification, mostly under "Lock und Warnruf." It is impossible, however, to recognize any particular notes from his elaborate syllabic representations. It is our belief that some of these represent incomplete calls of other types. Certainly listening to the tape recordings suggests this, for these notes often follow or precede complete, clear-cut calls and seem to be fragments of them. At any rate, these clucks or "call notes," to use Tinbergen's (1953) term, seem to be only loosely related to feeding, being heard more often among a large group of feeding gulls. The other calls also, except for the alarm call, were most common during feeding.

A possible "departing call."—One other call seems worthy of mention. This is what might be called a "departing call," matching that reported by Faber (1936) in Orthoptera. If a group of gulls were sitting on the water and one flew up suddenly and silently, the others often rose into the air also. This was noted also by Goethe (1937) at the breeding grounds. Usually, however, if a gull rose off the water without obvious alarm, it would emit a very brief, low, two-noted call, without easily definable tonal qualities, but very characteristic once heard. This seemed to have the effect of keeping the others on the water. Obviously, the testing of this call is very

difficult, because its essential result is to maintain the *status quo* among the gulls hearing it. This observation is presented merely as suggestive and should be subjected to critical testing. Suffice it to say that we could recognize this call ourselves and knew, without seeing, when a gull was leaving a group.

The young gulls only gradually develop the ability to produce these and other calls, as all previous workers have noted. Juvenile Herring Gulls emit only high-pitched squeaks, sometimes sounding like falsetto versions of the food-finding call. Older juveniles have these squeaks, plus a rasping rattle which they emit at feeding areas. These squeaks and rattles are quite attractive, when recorded and played back to gulls, both young and adults. Being of high frequency, they do not carry as well as the food-finding call of the adults, but are attractive for those within hearing range.

Summary of Mechanisms used in Food-finding

The food-finding behavior of the Herring Gull, under the conditions observed, involves the following:

1. Almost constant visual surveillance of all parts of the sea-coast by a few, and constant auditory surveillance by many gulls.

2. Visual recognition of food by gulls. This, in the case of fish, apparently is first by the sight of shiny objects being thrown or lying near the water's edge. Only if the fish can be identified as such, on closer examination, however, will the gulls try to feed. Visual cues may easily be reinforced by learning, if feeding occurs regularly at a given spot, causing the gulls to come almost as soon as a person appears or is in the act of throwing.

3. Visual attraction of small groups. The flight pattern of Herring Gulls that have found food is attractive to other gulls which can see the pattern, yet may not be able to see the food. This can result in the appearance on the scene of a small number of gulls.

4. Auditory attraction of large groups. Usually, one of the gulls visually attracted emits a special call, which we have named the food-finding call. This attracts most gulls within hearing, which apparently may be up to 3 to 5 km. distant across open water. As new arrivals come, they too emit the call and more are attracted.

5. Formation of the interest-group and feeding. Usually the gulls first form a group near the food. This arouses the interest of any flying gulls which see it, even if the gulls are silent, and the group grows. From this group individuals fly over the food. If one lands to feed, the others fly in and the welter of calls which then arises may attract still more distant gulls. Shortly the gulls return to the interest-group and await further feeding. Even when food is continuously present, feeding seems to be more or less rhythmic

from interest-groups. If a person throws some more fish, or if a new individual alights to feed, the others again fly to the food, with much noise. Shortly, however, the gulls return to the group area, often leaving some food untouched, to repeat the feeding rush as before within a short time.

General Discussion

Most of the interest in behavior of birds has been in breeding, nesting, and migration. The feeding activities of birds, however, also offer a rich field for study of communication and social behavior. It is tempting to theorize at this point, and to point out that the communication here studied is for the purpose of social assistance and not competition, as is usually studied in experiments on feeding. We prefer, however, to present our data and interpretations without attempts to fit them into any existing theories or to devise new ones.

One item seems worthy of serious note. Earlier workers who studied reactions to or production of sounds by gulls have published detailed reports of their findings. In these, they use syllables or occasionally musical notations to represent the calls of the birds. One soon finds, however, that only their descriptions of the behavior of the gulls allow him to correlate these calls with those he has heard. As Armstrong (1947:75) writes, "Without recording apparatus appreciations of bird song are apt to be so subjective that their scientific value is questionable." Obviously it now is possible to record bird calls easily and to break them down from mere "songs" into informational bits by means of tape recording. With this arises a need for some means of communication among workers, and this obviously is impossible by syllables or bare musical notes which are meaningless without personal explanation.

Field recordings of sounds of animals to which the observer adds, at the same time, oral descriptions of behavior are excellent for later study. They allow the observer to keep a continuous watch on the animals and yet to record immediately his observations. Tinbergen (1953:164) notes that his moving pictures showed a particular posture of the gull in its charge flight which he had never noticed in the field. This sort of thing happens also with sound recordings. In one of our recordings, for instance, the observer remarks that she has not heard the food-finding call, yet the gulls are coming in. Only about five seconds before this remark was made, however, the call is clearly recorded, obviously being given by a gull not in the group on which the observers' attention was fastened. This human tendency to focus attention on some phase of the environment to the exclusion of others may be valuable for much work, but it can lead to mistaken observations in broad field situations. The tape recording, played in a

quiet room, without visual distractions, quickly reveals the true situation. As Tinbergen (1953:164) writes, "It teaches one to be very careful in claiming that this or that does not happen because one has never seen it oneself." One might add "heard it oneself," as well.

A word might be said in a practical vein. Many animals which are pests—rodents, birds, insects—produce and receive sounds. Some of these sounds almost certainly are used by these animals for communication. If recorded, they might be used to induce behavior patterns which would aid in control of the pest species. These biologically significant sounds have advantages over mere noise or high intensity sounds: they are specific or nearly so; they need not be emitted at such high intensities that cost is prohibitive; they afford little or no danger to man. The possible future use of sounds in pest control will require many careful studies of behavior of animals in all their life-activities, and especially of their means of communication. It is to be hoped that increased interest in possible practical results will stimulate—and help to secure payment for—much-needed fundamental research in this field.

Summary

Visual and auditory communication in food-finding behavior of Herring Gulls on the sea-coast of Maine were studied using recording techniques to separate the two mechanisms. The gulls can be attracted visually by flashing objects of suitable size and by a typical flight-pattern of individuals that have found food. The major attractant outside the visual field, however, is a special call emitted by gulls that discover food. A study of sounds made by non-breeding gulls at food sources allows the designation of at least four distinct calls: (1) food-finding call, (2) alarm call, (3) trumpeting, and (4) mew call. These were recorded in the field with a tape recorder, and the reactions of gulls to broadcasts of the recorded calls were studied. The food-finding call attracts gulls from distances up to 3 to 5 km. The alarm call repels gulls from food or resting places. Trumpeting elicits only chorusing of nearby gulls. The mew call evokes no consistent reactions under these circumstances. Gulls also have a number of single call-notes, the functions of which are not clear. The alarm call of Herring Gulls induces Great Black-backed Gulls and Laughing Gulls also to fly away from the source of the sound.

Acknowledgments

Paper No. 1950, Pennsylvania Agricultural Experiment Station. This work was sponsored in part by the U.S. Air Force by the Aero-Medical Laboratory, Wright Air Development Center, Wright-Patterson Air Force Base, Dayton, Ohio, under Contract No. AF 33(038)-786.

Literature Cited

Armstrong, E. A.
1947 Bird display and behaviour. London; Lindsay Drummond Ltd.

Bent, A. C.
1921 Life histories of North American gulls and terns. *U.S. Nat. Mus. Bull.* 113.

Boss, W. R.
1943 Hormonal determination of adult characters and sex behavior in herring gulls (*Larus argentatus*). *Jour. Exp. Zool.*, 94:181–206.

Collias, N. and M. Joos
1953 The spectrographic analysis of sound signals of the domestic fowl. *Behaviour*, 5:175–188.

Donner, K. O.
1951 The visual acuity of some passerine birds. *Acta Zool. Fenn.*, 66:1–40.

Dutcher, W. and W. L. Baily
1903 A contribution to the life history of the herring gull (*Larus argentatus*) in the United States. *Auk*, 20:417–431.

Faber, A.
1936 Die Laut- und Bewegungsäusserungen der Oedipodinen. Biologisch, tierpsychologisch und vergleichendfunktionell beschrieben; mit einem Erstnachweis von tonhaften Lauten bei Acridiiden und mehrfachen Lautformen bei Weibchen. Allgemeines zur Biologie der Paarungseinleitung und Paarung. *Zeits. wiss. Zool.*, 149:1–85.

Frings, H., M. Frings, B. Cox and L. Peissner
1955 Recorded calls of herring gulls (*Larus argentatus*) as repellents and attractants. *Science*, 121:340–341.

Goethe, F.
1937 Beobachtungen und Untersuchungen zur Biologie der Silbermöwe (*Larus a. argentatus Pontopp.*) auf der Vogelinsel Memmertsand. *Jour. Ornith.*, 85:1–119.

Portielje, A. F. J.
1928 Zur Ethologie bezw. Psychologie der Silbermöwe, *Larus argentatus argentatus* Pont. *Ardea*, 17:112–149.

Strong, R. M.
1914 On the habits and behavior of the Herring Gull, Larus argentatus Pont. *Auk*, 31:22–49; 178–199.

Tinbergen, N.
1953 The herring gull's world. London; Collins.

Department of Zoology and Entomology, Pennsylvania State University, University Park, Pennsylvania, March 30, 1955